Claims

1. A device for detecting energy generated by non-radiative decay in a substance on irradiation with electromagnetic radiation comprising

a radiation source adapted to generate a series of pulses of electromagnetic radiation,

a transducer having a pyroelectric or piezoelectric element and electrodes which is capable of transducing the energy generated by the substance into an electrical signal, and

a detector which is capable of detecting the electrical signal generated by the transducer,

wherein the detector is adapted to determine the time delay between each pulse of electromagnetic radiation from the radiation source and the generation of the electric signal.

2. A device as claimed in claim 1, wherein the substance is an analyte or a complex or derivative of the analyte, the device being used for detecting the analyte in a sample, the device further comprising

at least one reagent proximal to the transducer, the reagent having a binding site which is capable of binding the analyte or the complex or derivative of the analyte,

wherein the analyte or the complex or derivative of the analyte is capable of absorbing the electromagnetic radiation generated by the radiation source to generate energy,

wherein, in use, the energy is transduced into an electrical signal by the transducer and is detected by the detector, and the time delay between each of the pulses of electromagnetic radiation and the generation of the electric signal corresponds to the position of the analyte at any of one or more positions at different distances from the surface of the transducer.

3. A device as claimed in claim 2, wherein the reagent is an antibody and the analyte is an antigen.

4. A device as claimed in claim 3, wherein the complex or derivative of the analyte is a complex with a labelled antibody.

5. A device as claimed in claim 3, wherein the analyte is a labelled antigen and the electrical signal detected by the detector is inversely proportional to the presence of an unlabelled antigen in the sample.

6. A device as claimed in claim 4 or 5, wherein the labelled antibody or antigen is labelled with a label selected from a dye molecule, a gold particle, a coloured-polymer particle, a fluorescent molecule, an enzyme, a red blood cell, a haemoglobin molecule, a magnetic particle and a carbon particle.

7. A device as claimed in claim 2, wherein the reagent is a first nucleic acid and the analyte is a second nucleic acid and the first and second nucleic acids are complementary.

8. A device as claimed in claim 2, wherein the reagent contains avidin or derivatives thereof and the analyte contains biotin or derivatives thereof, or vice versa.

9. A device as claimed in claim 1, which is suitable for monitoring the progress of a reaction between reactants, further comprising at least one substance proximal to the transducer, the substance being capable of absorbing the electromagnetic radiation generated by the radiation source to generate energy, wherein, in use, the energy generated is transduced into an electrical signal by the transducer and is detected by the detector, and the time delay between each of the pulses of electromagnetic radiation and the generation of the electric signal and/or the magnitude of the signal at a specific time delay varies as the reaction progresses.

10. A device as claimed in claim 9, wherein the reaction is a polymerisation or depolymerisation reaction.

11. A device as claimed in any preceding claim, wherein the time delay is at least 5 milliseconds, preferably at least 10 milliseconds.

12. A device as claimed in any preceding claim, wherein the time delay is no greater than 500 milliseconds, preferably no greater than 250 milliseconds, more preferably no greater than 150 milliseconds.

13. A device as claimed in any preceding claim, wherein the electromagnetic radiation is light, preferably visible light.

14. A device as claimed in any preceding claim, wherein the reagent is adsorbed on to the transducer.

15. A device as claimed in any of claims 2 to 13, wherein the analyte according to any of claims 2 to 8 or the reactants according to claims 9 or 10 are dissolved or suspended in a liquid.

16. A device as claimed in claim 14, further comprising a well for holding the liquid in contact with the transducer.

17. A device as claimed in any preceding claim, further comprising a chamber for storing one or more additional reagents.

18. A device as claimed in claim 16, wherein the additional reagent is a labelled antibody for producing the subsequently formed complex or derivative of the analyte.

19. A method for detecting energy generated by non-radiative decay in a substance on irradiation with electromagnetic radiation, comprising the steps of
irradiating the substance with a series of pulses of electromagnetic radiation to generate energy,
transducing the change in energy to an electrical signal using a transducer having a pyroelectric or piezoelectric element and electrodes which is capable of transducing a change in energy to an electrical signal,
detecting the electrical signal generated by the transducer, and
determining the time delay between each pulse of electromagnetic radiation from the radiation source and the generation of the electric signal.

20. A method for detecting an analyte in a sample, comprising the steps of exposing the sample to a transducer having a pyroelectric or piezoelectric element and electrodes which is capable of transducing a change in energy to an electrical signal, the transducer having at least one reagent proximal thereto, the reagent having a binding site which is capable of binding the analyte or a complex or derivative of the analyte, the analyte or the complex or derivative of the analyte being capable of absorbing the electromagnetic radiation generated by the radiation source to generate energy by non-radiative decay;

irradiating the reagent with a series of pulses of electromagnetic radiation,

transducing the energy generated into an electrical signal;

detecting the electrical signal and the time delay between each pulse of electromagnetic radiation from the radiation source and the generation of the electric signal, wherein the time delay between each of the pulses of electromagnetic radiation and the generation of the electric signal corresponds to the position of the analyte at any of one or more positions at different distances from the surface of the transducer.

21. A method as claimed in claim 20, wherein the reagent is an antibody and the analyte is an antigen.

22. A method as claimed in claim 21, wherein the complex or derivative of the analyte is a complex with a labelled antibody.

23. A method as claimed in claim 21, wherein the analyte is a labelled antigen and the electrical signal detected by the detector is inversely proportional to the presence of an unlabelled antigen in the sample.

24. A method as claimed in claim 22 or 23, wherein the labelled antibody or antigen is labelled with a label selected from a dye molecule, a gold particle, a coloured-polymer particle, a fluorescent molecule, an enzyme, a red blood cell, a haemoglobin molecule, a magnetic particle and a carbon particle.

25. A method as claimed in claim 20, wherein the reagent is a first nucleic acid and the analyte is a second nucleic acid and the first and second nucleic acids are complimentary.

26. A method as claimed in claim 20, wherein the reagent contains avidin or derivatives thereof and the analyte contains biotin or derivatives thereof, or vice versa.

27. A method as claimed in any of claims 20 to 26, wherein the method is carried out without removing the sample from the transducer between the steps of exposing the sample to the transducer and irradiating the reagent.

28. A method for monitoring the progress of a reaction comprising the steps of exposing reactants in a reaction medium to a transducer having a pyroelectric or piezoelectric element and electrodes which is capable of transducing a change in energy to an electrical signal, the transducer having at least one substance proximal to the transducer, the substance being capable of absorbing the electromagnetic radiation generated by the radiation source to generate energy by non-radiative decay,
irradiating the substance with a series of pulses of electromagnetic radiation,
transducing the energy generated into an electrical signal;
detecting the electrical signal and the time delay between each pulse of electromagnetic radiation from the radiation source and the generation of the electric signal, wherein the time delay between each of the pulses of electromagnetic radiation and the generation of the electric signal and/or the magnitude of the signal at a specific time delay varies as the reaction progresses.

29. A method as claimed in claim 28, wherein the reaction is a polymerisation or depolymerisation reaction.